

Appendix C Nominal Strengths and Testing

C-1. Nominal Strengths of Wire Rope

The following tables (C1 through C12) show the nominal strengths of different types of wire rope.

Table C1
6 x 9 Classification/Bright (Uncoated), FC

Nominal Diameter		Approximate Mass		Nominal Strength, Improved Plow Steel	
in.	mm	lb/ft	kg/m	Tons	Metric tons
5/8	16	0.66	0.98	16.7	15.1
3/4	19	0.95	1.41	23.8	21.6
7/8	22	1.29	1.92	32.2	29.2
1	26	1.68	2.5	41.8	37.9
1-1/8	29	2.13	3.17	52.6	47.7
1-1/4	32	2.63	3.91	64.6	58.6
1-3/8	35	3.18	4.73	77.7	70.5
1-1/2	38	3.78	5.63	92.0	83.5
1-5/8	42	4.44	6.61	107	97.1
1-3/4	45	5.15	7.66	124	112
1-7/8	48	5.91	8.8	141	128
2	52	6.72	10.0	160	145
2-1/8	54	7.59	11.3	179	162
2-1/4	57	8.51	12.7	200	181
2-3/8	60	9.48	14.1	222	201
2-1/2	64	10.5	15.6	244	221

Table C2
6 x 19 Classification/Bright (Uncoated), IWRC

Nominal Diameter		Approximate Mass		Nominal Strength, Plow Steel			
				Improved		Extra Improved	
in.	mm	lb/ft	kg/m	Tons	Metric Tons	Tons	Metric Tons
5/8	16	0.72	1.07	17.7	16.2	20.6	18.7
3/4	19	1.04	1.55	25.6	23.2	29.4	26.7
7/8	22	1.42	2.11	34.6	31.4	39.8	36.1
1	26	1.85	2.75	44.9	40.7	51.7	46.9
1-1/8	29	2.34	3.48	56.5	51.3	65.0	59.0
1-1/4	32	2.89	4.30	69.4	63.0	79.9	72.5
1-3/8	35	3.5	5.21	83.5	75.7	96.0	87.1
1-1/2	38	4.16	6.19	98.9	89.7	114	103
1-5/8	42	4.88	7.26	115	104	132	120
1-3/4	45	5.67	8.44	133	121	153	139
1-7/8	48	6.5	9.67	152	138	174	158
2	52	7.39	11.0	172	156	198	180
2-1/8	54	8.35	12.4	192	174	221	200
2-1/4	57	9.36	13.9	215	195	247	224
2-3/8	60	10.4	15.5	239	217	274	249
2-1/2	64	11.6	17.3	262	238	302	274

Table C3
6 x 37 Classification/Bright (Uncoated), FC

Nominal Diameter		Approximate Mass		Nominal Strength, Improved Plow Steel	
in.	mm	lb/ft	kg/m	Tons	Metric tons
5/8	16	0.66	0.98	16.7	15.1
3/4	19	0.95	1.41	23.8	21.6
7/8	22	1.29	1.92	32.2	29.2
1	26	1.68	2.5	41.8	37.9
1-1/8	29	2.13	3.17	52.6	47.7
1-1/4	32	2.63	3.91	64.6	58.6
1-3/8	35	3.18	4.73	77.7	70.5
1-1/2	38	3.78	5.63	92.0	83.5
1-5/8	42	4.44	6.61	107	97.1
1-3/4	45	5.15	7.66	124	112
1-7/8	48	5.91	8.8	141	128
2	52	6.72	10.0	160	145
2-1/8	54	7.59	11.3	179	162
2-1/4	57	8.51	12.7	200	181
2-3/8	60	9.48	14.1	222	201
2-1/2	64	10.5	15.6	244	221

Table C4
6 x 37 Classification/Bright (Uncoated), IWRC

Nominal Diameter		Approximate Mass		Nominal Strength, Plow Steel			
				Improved		Extra Improved	
in.	mm	lb/ft	kg/m	Tons	Metric Tons	Tons	Metric Tons
5/8	16	0.72	1.07	17.7	16.2	20.6	18.7
3/4	19	1.04	1.55	25.6	23.2	29.4	26.7
7/8	22	1.42	2.11	34.6	31.4	39.8	36.1
1	26	1.85	2.75	44.9	40.7	51.7	46.9
1-1/8	29	2.34	3.48	56.5	51.3	65.0	59.0
1-1/4	32	2.89	4.30	69.4	63.0	79.9	72.5
1-3/8	35	3.5	5.21	83.5	75.7	96.0	87.1
1-1/2	38	4.16	6.19	98.9	89.7	114	103
1-5/8	42	4.88	7.26	115	104	132	120
1-3/4	45	5.67	8.44	133	121	153	139
1-7/8	48	6.5	9.67	152	138	174	158
2	52	7.39	11.0	172	156	198	180
2-1/8	54	8.35	12.4	192	174	221	200
2-1/4	57	9.36	13.9	215	195	247	224
2-3/8	60	10.4	15.5	239	217	274	249
2-1/2	64	11.6	17.3	262	238	302	274

Table C5
6 x 61 Classification/Bright (Uncoated), FC

Nominal Diameter		Approximate Mass		Nominal Strength, Improved Plow Steel	
in.	mm	lb/ft	kg/m	Tons	Metric tons
1	26	1.68	2.50	39.8	36.1
1-1/8	29	2.13	3.17	50.1	45.4
1-1/4	32	2.63	3.91	61.5	55.8
1-3/8	35	3.18	4.73	74.1	67.2
1-1/2	38	3.78	5.63	87.9	79.7
1-5/8	42	4.44	6.61	103	93.4
1-3/4	45	5.15	7.66	119	108
1-7/8	48	5.91	8.80	136	123
2	52	6.77	10.1	154	140
2-1/8	54	7.59	11.3	173	157
2-1/4	57	8.51	12.7	193	175
2-3/8	60	9.48	14.1	214	194

Table C6
6 x 61 Classification/Bright (Uncoated), IWRC

Nominal Diameter		Approximate Mass		Nominal Strength, Plow Steel			
				Improved		Extra Improved	
in.	mm	lb/ft	kg/m	Tons	Metric Tons	Tons	Metric Tons
1	26	1.85	2.75	42.8	38.8	49.1	44.5
1-1/8	29	2.34	3.48	53.9	48.9	61.9	56.2
1-1/4	32	2.89	4.30	66.1	60.0	76.1	69.0
1-3/8	35	3.50	5.21	79.7	72.3	91.7	83.2
1-1/2	38	4.16	6.19	94.5	85.7	109	98.9
1-5/8	42	4.88	7.26	111	101	127	115
1-3/4	45	5.67	8.44	128	116	146	132
1-7/8	48	6.50	9.67	146	132	168	152
2	52	7.39	11.0	165	150	190	172
2-1/8	54	8.35	12.4	186	169	214	194
2-1/4	57	9.36	13.9	207	188	239	217
2-3/8	60	10.40	15.5	230	209	264	240

Table C7
6 x 25 B, 6 x 27 H, 6 x 30 G Flattened Strand/Bright (Uncoated), FC

Nominal Diameter		Approximate Mass		Nominal Strength, Improved Plow Steel	
				Tons	Metric tons
in.	mm	lb/ft	kg/m	Tons	Metric tons
5/8	16	0.70	1.04	18.3	16.6
3/4	19	1.01	1.50	26.2	23.8
7/8	22	1.39	2.07	35.4	32.1
1	26	1.80	2.68	46.0	41.7
1-1/8	29	2.28	3.39	57.9	52.5
1-1/4	32	2.81	4.18	71.0	64.4
1-3/8	35	3.40	5.06	85.5	77.6
1-1/2	38	4.05	6.03	101	91.6
1-5/8	42	4.75	7.07	118	107
1-3/4	45	5.51	8.20	138	123
1-7/8	48	6.33	9.42	155	141
2	52	7.20	10.70	176	160

Table C8
6 x 25 B, 6 x 27 H & 30 G Flattened Strand/Bright (Uncoated), IWRC

Nominal Diameter		Approximate Mass		Nominal Strength, Plow Steel			
				Improved		Extra Improved	
in.	mm	lb/ft	kg/m	Tons	Metric Tons	Tons	Metric Tons
5/8	16	0.73	1.09	19.6	17.8	21.7	19.7
3/4	19	1.06	1.58	28.1	25.5	31	28.1
7/8	22	1.46	2.17	38.0	34.5	41.9	38
1	26	1.89	2.83	49.4	44.8	54.4	49.4
1-1/8	29	2.39	3.56	62.2	56.4	68.5	62.1
1-1/4	32	2.95	4.39	76.3	69.2	84	76.2
1-3/8	35	3.57	5.31	91.9	83.4	101	91.6
1-1/2	38	4.25	6.32	108	98	119	108
1-5/8	42	4.98	7.41	127	115	140	127
1-3/4	45	5.78	8.60	146	132	161	146
1-7/8	48	6.65	9.90	167	152	184	167
2	52	7.56	11.3	189	171	207	188

Table C9
8 x 19 Classification/Bright (Uncoated), FC

Nominal Diameter		Approximate Mass		Nominal Strength, Improved Plow Steel	
in.	mm	lb/ft	kg/m	Tons	Metric tons
5/8	16	0.61	0.91	14.3	13.0
3/4	19	0.88	1.31	20.5	18.6
7/8	22	1.20	1.79	27.7	25.1
1	26	1.57	2.34	36.0	32.7
1-1/8	29	1.99	2.96	45.3	41.1
1-1/4	32	2.45	3.65	55.7	50.5
1-3/8	35	2.97	4.42	67.1	60.7
1-1/2	38	3.53	5.25	79.4	72.0

Table C10
6 x 19 and 6 x 37 Classification/Bright (Uncoated), IWRC

Nominal Diameter		Approximate Mass		Nominal Strength, Plow Steel	
				Improved	
in.	mm	lb/ft	kg/m	Tons	Metric Tons
5/8	16	0.72	1.07	22.7	20.6
3/4	19	1.04	1.55	32.4	29.4
7/8	22	1.42	2.11	43.8	39.7
1	26	1.85	2.75	56.9	51.6
1-1/8	29	2.34	3.48	71.5	64.9
1-1/4	32	2.89	4.30	87.9	79.8
1-3/8	35	3.5	5.21	106	95.8
1-1/2	38	4.16	6.19	125	113
1-5/8	42	4.88	7.26	146	132
1-3/4	45	5.67	8.44	169	153
1-7/8	48	6.5	9.67	192	174
2	52	7.39	11.0	217	198
2-1/8	54	8.35	12.4	243	220
2-1/4	57	9.36	13.9	272	246
2-3/8	60	10.4	15.5	301	274
2-1/2	64	11.6	17.3	332	301

Table C11
Compacted Strand Wire Rope, 6 x 19 and 6 x 37 Classification/Bright (Uncoated), FC & IWRC

Nominal Diameter		Approximate Mass				Nominal Strength			
		lb/ft		kg/m		Tons		Metric Tons	
in.	mm	FC	IWRC	FC	IWRC	FC	IWRC	FC	IWRC
5/8	16	.71	.78	1.06	1.16	20.2	22.7	18.3	20.6
3/4	19	1.03	1.13	1.53	1.68	28.8	32.4	26.1	29.4
7/8	22	1.40	1.54	2.08	2.29	39.0	43.8	35.4	39.7
1	26	1.82	2.00	2.71	2.98	50.7	56.9	46.0	51.6
1-1/8	29	2.31	2.54	3.44	3.78	63.6	71.5	57.7	64.9
1-1/4	32	2.85	3.14	4.24	4.67	78.2	87.9	70.9	79.7
1-3/8	35	3.45	3.80	5.13	5.65	94.1	106	85.4	96.1
1-1/2	38	4.10	4.50	6.10	6.70	111	125	101	113
1-5/8	42	4.80	5.27	7.14	7.84	130	146	118	132
1-3/4	45	5.56	6.12	8.27	9.11	150	169	136	153
1-7/8	48	6.38	7.02	9.49	10.4	171	192	155	174
2	51	7.26	7.98	10.8	11.9	193	217	175	197

Table C12
Compacted (Swaged) Wire Rope, 6 x 19 and 6 x 37 Classification/Bright (Uncoated), IWRC

Nominal Diameter		Approximate Mass		Nominal Strength	
				Extra Improved Plow Steel	
in.	mm	lb/ft	kg/m	Tons	Metric Tons
5/8	16	0.87	1.29	24.2	22.0
3/4	19	1.25	1.86	34.9	31.7
7/8	22	1.70	2.53	47.4	43.0
1	26	2.22	3.30	62.0	56.3
1-1/8	29	2.80	4.16	73.5	66.7
1-1/4	32	3.40	5.05	90.0	81.8
1-3/8	35	4.20	6.24	106.0	96.2
1-1/2	38	5.00	7.43	130.0	118.0

C-2. General Testing Information

Note that zinc, tensile, torsion, and preforming requirements should be considered for inclusion in the specifications for wire rope for lifting devices for Corps applications. The tests in this appendix can be used to verify those requirements.

C-3. Zinc-Coating Test

a. General. The zinc coating shall be tested for weight by the hydrochloric (muriatic) acid-antimony chloride method, also called the stripping method. The specimens shall be cleaned with an organic solvent, rinsed in water, and dried. The surface shall be considered to be sufficiently clean when the water rinse shows freedom from "water breaks," that is, when the water wets the entire surface.

b. Preparation the stripping solution. Twenty grams (20 g) of antimony trioxide (Sb_2O_3) or 32 g of antimony trichloride (SbCl_3) shall be dissolved in 1,000 milliliters (ml) of concentrated hydrochloric acid (HCl) having a specific gravity of approximately 1.19. To prepare the zinc stripping solution, 5 ml of the antimony chloride solution shall be added to each 1,000 ml of concentrated hydrochloric acid having a specific gravity of approximately 1.19.

c. Cleaning procedure. The specimen cleaned in accordance with Table C13 shall be weighed to the nearest 0.01 g.

(1) The zinc coating shall be stripped from the weighted specimen by immersing it in the stripping solution until the evolution of hydrogen ceases, or until only few bubbles are evolved. If the vessel used for the stripping bath is of small size, the specimen shall be loosely coiled to facilitate complete immersion. The temperature of the stripping solution shall at no time exceed 100°F. The same solution may be repeatedly used without further additions of antimony chloride solution until the time for stripping becomes inconveniently long.

(2) After stripping, the specimen shall be washed and scrubbed under running water and dried.

(3) The weight of the stripped specimen shall be determined to the nearest 0.01 g.

(4) The diameter of the stripped specimen, in inches, shall be determined by taking the mean of two measurements at right angles to each other. The measurements shall be made to the nearest 0.001 in.

(5) The weight of zinc coating shall be calculated as follows:

$$A = (W_1 - W_2) / (W_2 \times d \times 163) \quad (\text{C1})$$

where

A = weight of zinc coating in ounces per square foot of stripped wire surface

Table C13
Weight of Zinc Coating in Rope and Strand Wires Removed from Finished Rope

Galvanized at Finish Size		Drawn Galvanized Wire	
Wire Diameter, in.	Minimum Weight of Zinc Coating, ounce per square foot	Wire Diameter, in.	Minimum Weight of Zinc Coating, ounce per square foot
0.010 - 0.015	0.05	0.010 - .015	0.05
0.0155 - 0.27	.10	Over .015 - .028	.10
.028 - .047	.20	Over .028 - .060	.20
.048 - .054	.40	Over .060 - .090	.30
.055 - .063	.50	Over .090 - .140	.40
.063 - .079	.60		
.093 - .092	.70		
.093 - larger	.80		

W_1 = original weight of specimen

W_2 = stripped weight of specimen

d = diameter of stripped wire, in.

163 = constant

C-4. Tensile Strength

a. Ropes and strands. The strength of wire rope or strands shall be determined from the long samples. The accepted breaking strength shall be as shown in the applicable tables herein. The free length of wire rope or strand shall be as shown in Table C14. The rope ends shall be terminated in zinc-poured sockets or other approved attachments. A failure with less than the accepted breaking strength that occurs within three times the rope or strand diameter of the end attachment shall be considered “no test” and further testing shall proceed as though the test never occurred.

b. Main wires. From each short sample, no less than one specimen of each diameter of wire from each wire strand and not less than six specimens from each sample shall be selected and the tensile strength determined in accordance with ASTM E 1571. The free length of wires shall be not less than 10 in. The speed of the movable head of the testing machine under no load shall be not more than 1 in. per minute. The tensile strength of the main wires shall conform

to the tensile strength requirements shown in Table C15.

C-5. Torsion Test

a. Primary method. From each short sample not less than one specimen of each size of main wires from each strand shall be taken. The total number of specimens shall be not more than 25 percent of the total number of main wires. The distance between the jaws of the testing machine shall be $8 \pm 1/16$ in. One clamp in the testing machine shall be movable parallel to the axis of the tested wire, and an axial tensile force in accordance with Table C16 shall be applied to keep the tested wire straight during the test. The tested wire shall be twisted by rotating one or both of the clamps at a uniform rate of not more than 60 revolutions per minute. The wires shall not break when one end is held and the other rotated the number of revolutions (360 degrees) as shown in Table C17.

b. Alternative test procedure. Because the number of revolutions in the torsional test is proportional to the free length, the inspector may allow a free length before the test of $4 \pm 1/16$ in. for wires up to 0.040 in. in diameter or of $6 \pm 1/16$ in. for wires not more than 0.060 in. in diameter. Wire specimens with a free length of 4 in. shall not break when twisted one-half the number of revolutions shown in Table C17. Wire specimens with a free length of 6 in. shall not break when twisted three-fourths the number of

Table C15
Minimum Free Length of Wire Rope and
Strand for Tensile Test

Size Range, in.	Recommended Length ¹ , ft (minimum)
1/64 - 1/4	2
5/16 - 3/4	4
7/8 and larger	6

¹ These lengths represent clear rope between attachments.

revolutions shown in Table C16. Testing shall be done in the same manner as described above.

C-6. Preformed Wire Rope

If the seizing at one end of the wire is removed, the difference between the nominal diameter of the wire rope and the nominal diameter before seizing is removed shall be not more than the values given in Table C18.

Table C16
Tensile Strength Requirements of Main Wires Removed from Finished Rope

Material	Tensile Strength, minimum	
	Uncoated or Drawn Galvanized	Galvanized at Finish Size
Designated Commercially as:	lb/in ²	lb/in. ²
Iron	700,000	55,000
Annealed Steel	--	60,000
Traction Steel	160,000	--
Improved Plow Steel		
0.030 in. diameter and smaller	244,000	219,000
.031 - .060 in.	238,000	214,000
.061 - .100 in.	230,000	207,000
.101 - .140 in.	225,000	202,000
.141 - .190 in.	218,000	196,000
.191 - .250 in.	209,000	--
Extra Improved Plow Steel:		--
0.030 in. diameter and smaller	268,000	--
.031 - .060 in.	262,000	--
.061 - .100 in.	253,000	--
.101 - .140 in.	248,000	--
.141 - .190 in.	240,000	--
.191 - .250 in.	230,000	--
Phosphor bronze	90,000	--
Corrosion resistant steel	205,000	--

Table C17
Tensile Force on Wires During Torsional Test

Wire Diameter, in.		Tensile Force, lb	
From	To	Minimum	Maximum
0.000	0.009	0.5	1
.010	.014	1.0	2
.015	.019	1.5	3
.020	.029	2.0	4
.030	.039	3.0	6
.040	.049	4.0	8
.050	.059	5.0	10
.060	.069	6.0	12
.070	.079	7.0	14
.080	.089	8.0	16
.090	.099	9.0	18
.100	.109	10.0	20
.110	.119	11.0	22
.120	.129	12.0	24
.130	.139	13.0	26
.140	.149	14.0	28
.150	.159	15.0	30
.160	.169	16.0	32
.170	.189	19.0	38
.190	.209	22.0	44
.210	.229	25.0	50
.230	.249	28.0	56

Table C18
Torsion Values for Bright (Uncoated) and Drawn-Galvanized Main Wires Removed From Finished Rope

Material	Torsion (revolutions) per 100-wire diameter in length ¹
Extra improved plow steel	27.0 - 100 d ²
Improved plow steel	28.0 - 25 d ²
Traction steel	30.5 - 25 d ²

¹ To convert to torsions in 8 in., divide torsions in 100 d by 12.5 d.

² d = diameter of wire. Zinc coated (galvanized) at finished size main wires will not be required to meet these torsion values.

Table C19
Allowable Increases in Rope Diameter

Diameter before seizing is removed, in.	Increase in diameter after seizing is removed, in.
0 to 3/4	1/32
13/16 to 1-1/8	3/64
1-3/16 to 1-1/2	1/16
1-9/16 to 2-1/4	3/32
2-5/16 and larger	1/8